Tatemi SHIMIZU*: Cytogeographical notes on *Chrysanthemum Makinoi*

清水建美*: リュウノウギクの4倍体の発見について

It is well-known that *Chrysanthemum Makinoi* Matsum. et Nakai is diploid (2n=18)[1),2)]. Its area of distribution is middle Honshu to east Kyushu in Japan. On one hand, however, *C. Makinoi* occurring on the Japan Sea side of Honshu was proved to be tetraploid (2n=36) and named var. *wakasaense*[3),4)]. According to Huziwara[5)], it is strictly confined to the coast of Prefectures of Tottori, Kyoto and Fukui. On the other hand, I found that *C. Makinoi* from Mt. Ibuki in Pref. Shiga of Honshu was also tetraploid**.

The purpose of this paper is to report the results of the later study and to approach to some phytogeographical problems of the new tetraploid race of *C. Makinoi*.

Material plants and their habitats

After my roport** of the tetraploid *C. Makinoi* which was based upon only a small number of materials, more than sixty and fifteen living samples were brought from Mt. Ibuki and its nearest peak Mt. Ryôzen, respectively. Both of Mt. Ibuki (1377 m) and Mt. Ryôzen (1084 m) are mainly constructed by the permo-carboniferous limestone, escarpments and gravelly places being easily found at upper elevation. *C. Makinoi* is much abundant there especially on open calcareous grassland, while it can be rarely found on the floors of forests or bushes. The material plants were sampled at random from foot to summit; most from calcareous habitat and a few siliceous one.

In addition to these materials, some samples came to my hand from Mt. Myôjô in Pref. Niigata (limestone), Mt. Hakusan in Pref. Ishikawa (andesite), Mt. Hiei in Pref. Kyôto (granite), Mt. Nonobori in Pref. Mie (granite), Mt. Senjô in Pref. Tottori (andesite) and Mt. Ishidate in Pref. Kôchi (limestone).

For subsequent revision, flowering shoots of these materials are all preserved in the herbarium of the Kyôto University.

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Chromosome numbers and pollen grains

All of the materials mentioned above have been cytologically examined by means of squashed root tip cells. The somatic chromosome numbers of all the materials not only from Mt. Ibuki but also from Mt. Ryôzen are 36 (Fg.1 : A, B), and those from the other localities are 2n=18 likewise in other cases so far reported (Fig. 1 : C).

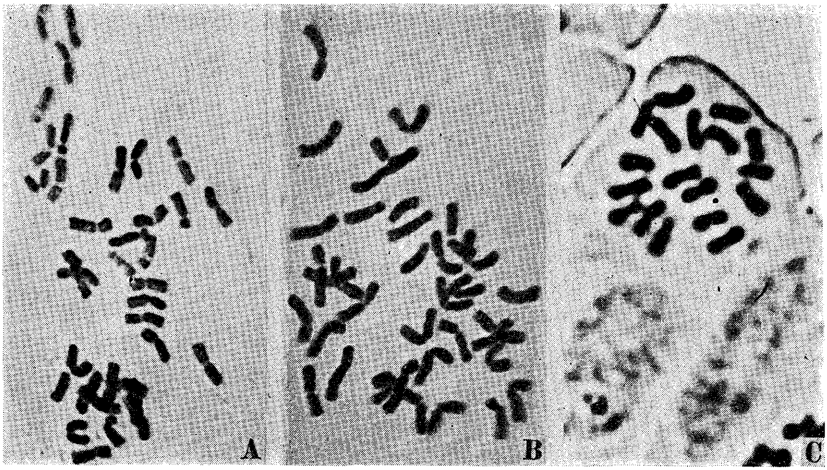

Fig. 1. Somatic chromosomes of *Chrysanthemum Makinoi* from limestone crevices of Mt. Ibuki (A), Mt. Ryozen (B) and Mt. Myojo (C).

Shimotomai and Tanaka$^{6)}$ revealed that pollen grains of *C. Makinoi* var. *wakasaense*, in spite of its relationship of polyploidy, were not different from those of the diploid *C. Makinoi* both in size and shape. As long as the tetraploid race from Mt. Ibuki and Mt. Ryôzen is concerned, however, it was found that pollen grains are evidently larger than those of *C. Makinoi* var *wakasaense* and rather elliptical in shape comparing with their spheric ones (Fig. 2). An example of this comparison of pollen size between the diploid race and the tetraploid one is shown in Table 1, where measurement was concerned with length of the longer axis of each mature grain.

Consideration

The origin of this tetraploid *C. Makinoi* is one of the most interested problems. *C. Makinoi* var. *wakasaense* is possible, though not easily, to be distinguished from var. *Makinoi* by its robuster stems, larger leaves, more numerous heads and shorter peduncles$^{3),4)}$. But, no specimens from Mt. Ibuki and Mt.

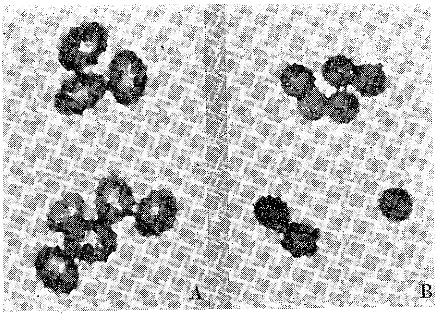

Fig. 2. Pollen grains of *C. Makinoi.* ×20.
A: Tetraploid race from Mt. Ibuki.
B: Diploid race from Mt. Hiei.

Tab. 1. Comparison of size and frequency of pollen grains.
I. Diploid race from Mt. Hiei.
II. Tetraploid race from Mt. Ibuki.

race size (μ)	I	II
20—25	54	0
25—30	191	6
30—35	47	58
35—40	6	187
40—45	0	66
45—50	0	30
mean (μ)	27.5	38.3

Ryôzen bear so robust stems and so large leaves as those of var. *wakasaense*. The variation of leaves in these two races will be seen in Fig. 3, where each leaf is denoted by the largest representative of each individual. Regarding pollen grains, the present tetraploid is larger than those of var. *wakasaense* as evident in the above. Furthermore, their ecological situations are also different, one in the coast and the other in the mountain far from the coast. Therefore, my conclusion is that the tetraploid in question is not referable to var. *wakasaense*. Probably, it may be not of hybrid origin such as between *C. indicum* and the diploid *C. Makinoi*. At Mt. Ibuki and Mt. Ryôzen, there seem to be absent

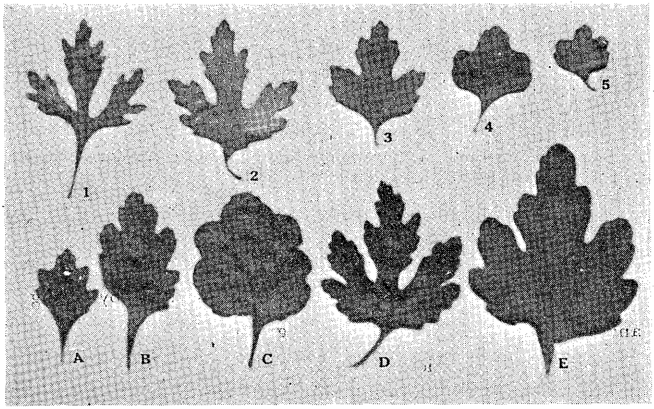

Fig. 3. Leaves of the tetraploid *C. Makinoi* (1—5) and of *C. Makinoi* var. *wakasaense* (A—E). ×1/3.

any other species of *Chrysanthemum*.

Then, the next question is whether the new tetraploid race is expected to be autopolyploid. Since chromosome size and form of *Chrysanthemum* species, as Dowrick7) pointed out, are not so variable both within and between the species, it is much difficult to decide the karyotype formulas. Unfortunately also in my case, some chromosomes are of difficulty to be decided if they are median or submedian as well as submedian or subterminal. Although the final decision of the karyotype formulas should owe to more elaborate investigations, my opinion is as follows:

Diploid *C. Makinoi* ....$K(2n)=18=8A^{m}+4B^{sm}+6C^{st}$;
Tetraploid *C. Makinoi* ....$K(2n)=36=16A^{m}+8B^{sm}+12C^{st}$;
or else, $K(2n)=36=16A^{m}+10B^{sm}+10C^{st}$.

It is of high probability, I suppose, that the new tetraploid race might be autopolyploid. If so, the formation of this autopolyploid will remain questionable.

At the juncture of my discovery of the present race, I just thought that its formation might be due to calcareous habitat. However, the material of Mt. Myôjô and M. Ishidate, though from limestone crevices, were proved to be diploid. Around Mt. Ibuki and Mt. Ryôzen, *C. Makinoi* is all tetraploid being indifferent to the habitats. This can be a proof that limestone does not necessarily play the decisive rôle for formation of the polyploid. It will be reasonably attributed to some geographical factors, which should be inquired into hereafter. But, it is worth notice that the tetraploid *C. Makinoi* does not occur on Mt. Nonobori, a member of the same mountain chain as Mt. Ibuki and Mt. Ryôzen. My attempt to detect the similar polyploid race from other localities by using herbarium materials and by estimating size of pollen grains has failed. Consequently, the present polyploid will be restricted to the Suzuka Mountains, but not occurring in the areas as south as Mt. Nonobori. Mt Fuziwara, representing the similar habitat to Mt. Ibuki and Mt. Ryôzen and situated south of the latters, may be the third station of the new tetraploid *C. Makinoi*.

Summary

Chrysanthemum Makinoi occurring on Mt. Ibuki and Mt. Ryôzen in middle Honshu of Japan was proved to be a new tetraploid race, $2n=36$. No diploid race could not be found there at any elevation and in any habitats. Pollen grains of this polyploid are distinct from those of the diploid *C. Makinoi* and of

var. *wakasaense*. Morphologically, it is not distinguishable from the diploid race. The present race is restricted to the areas surrounding Mt. Ibuki and Mt. Ryôzen, and mainly to calcareous habitat.

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1) Tahara, M., Bot. Mag. Tokyo **28**: 489 (1914). 2) Shimotomai, N. and T. Takemoto, Bot. Mag. Tokyo **50**: 324 (1936). 3) Kitamura, S., Acta Phytotax. Geobot. **7**: 70 (1938). 4) ————, Comp. Jap. **3**: 358 (1940). 5) Huziwara, Y., Acta Phytotax. Geobot. **17**: 129 (1958). 6) Shimotomai, N. and R. Tanaka, Bot. Mag. Tokyo **63**: 22 (1950). 7) Dowrick, G. J., Heredity **6**: 368 (1952).

○ メービウスの帯と染色体の倍化過程（前川文夫） Fumio MAEKAWA: Möbius' band as a process of autopolyploidy.

進化の根底に染色体の倍化と染色体の減量減少とがあることは再三のべた。ところで主な倍化の過程に2つある。一つは allopolyploidy 的な倍化で，交雑で生じた 2n 体がさらに機会を得て機能のある配偶子を生ずる道である。

今一つは autopolyploidy 的なコースで基本はこの方の倍化の機構である。私はこれには Möbius' band の機構が関連していると思う。これはたとえばテープを一ねじりしてつなぐと出来るが，表裏がきめられないのが特徴であり，また中央からたてに割目を入れて切りはなすと，直径が倍になった大きな，しかし細い環ができ上がる。もう1回ねじった場合は直径の同じ環が鎖になるが，さらに1回即ち3回ひねったものは，からまった1本の環になる。染色体が核内で有機的に活動している際に折りたたまれた1本につながっているとすればこれは環であり，分裂時に2本に分れる事は band の本質を持つことになるから細胞分裂時に染色体の縦断することは Möbius' band を種固有的に寸断したことになる。この際ねじれが奇数回起っていれば（多くは1回であろうが）染色体は2組にはなれずに1組としてつづいたものとなる。ねじれがなければ正常に2組にわかれる。もしも3回もねじれていてもテープではからまってしまうが染色体はそれ故にこそ分離しているからからまる危険はないのである。私には染色体の倍化は特に外因を要せず，染色体組のねじれの在り方で倍数化が極めて容易に起りうることは Möbius' band の原理がとり込まれているからであると考えたい。